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| Bulletin No. 1 | November, 1940 |



# Water Erosion of Soils in the Prairie Provinces

*Hordes of gullies now remind us*
*We should build our lands to stay;*
*And departing leave behind us*
*Fields that have not washed away.*
*Then when our boys assume the mortgage*
*On the land that's had our toil,*
*They'll not have to ask the question,*
*"Here's the farm, but where's the soil?"*

—Anonymous.

With apologies to Longfellow.

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THE NORTH-WEST LINE ELEVATORS ASSOCIATION
AGRICULTURAL DEPARTMENT of Agriculture
WINNIPEG, MANITOBA

# WATER EROSION OF SOILS IN THE PRAIRIE PROVINCES

K. W. NEATBY

*"No state that regards its future can afford to shut its eyes to such a menace."*

(W. D. Albright, Scientific Agriculture, Vol. 19, p. 242.)

## INTRODUCTION

It is estimated that, in the United States, wind and water erosion have ruined as productive land 50 million acres. This represents about one-sixth of the cultivated area. In addition, another 50 million acres have been more or less seriously damaged. Since many fields are affected by both wind and water erosion, it is difficult to assess the relative importance of these two soil destroying agencies. However, it is apparent from the results of surveys made by the United States Soil Conservation Service that water has caused much more damage than has wind.

In the prairie provinces of Canada, wind erosion, commonly called "soil drifting", has unquestionably caused more damage than has water erosion. However, the soil drifting problem is fairly well in hand though by no means solved. Losses of soil and water resulting from "run-off" are becoming more serious year by year, and are certainly not fully appreciated.

Canada is not the first nation to neglect or underestimate this problem. According to J. G. Lindley of the United States Soil Conservation Service, the French geographer, Elisee Reclus said, in 1873, that "among the causes which, in the history of mankind, have effected the extinction of so many forms of civilization we must place in the first order the reckless violence with which most nations have treated the soil which nourished them."

An American writer, Angus MacDonald, has this to say about the problem in Oklahoma: "Water erosion, in particular, escaped notice. The land was gradually whittled away; the changes, imperceptible at first, were discovered too late or ignored as unimportant. Even where erosion had reached a point where it could no longer be ignored, it did not receive the consideration that it merited." (Soil Conservation, April, 1937.)

Despite the fact that for many years far-seeing citizens of the United States, including George Washington himself, were aware that serious losses were being suffered; it was not until 1935 that, in the words of Dr. H. H. Bennett, "Congress for the first time recog-

nized accelerated erosion as a national menace and declared it to be the policy of Congress 'to provide permanently for the control and prevention of soil erosion and thereby to preserve natural resources.' "

Many centuries ago, before our present vegetative cover became established in the prairie provinces, erosion must have been very rapid. Evidence of this is provided by the immense valleys and coulees which wind their way through prairie and woodland. However, the establishment of grass and forest covers led to an approximate balance between soil loss and soil formation. It is apparent, therefore, that present day problems of erosion are primarily due to the destruction of native vegetation. **Our problem is to find some means of cultivating the soil and, at the same time, of preserving it.** Since hundreds of years are required for nature to replace one inch of lost soil, preventive measures should not be delayed.

## CAUSE OF WATER EROSION AND FACTORS WHICH AFFECT ITS RATE

The cause of water erosion is, obviously, running water. Just as air currents carry off soil, so do water currents. Both agencies cause a sort of "sifting out" of soil particles. The large particles (stone, gravel and coarse sand) are moved very short distances, or not at all; the fine sand and silt are deposited after relatively short journeys, while the finest particles may be carried for great distances. Thus the most valuable fractions, consisting of clay particles and organic matter, or humus, are those most easily lost.

Water erosion occurs in two forms, namely; sheet erosion and gully erosion. Sheet erosion is less obvious but often more damaging than gully erosion. It entails the loss of soil, in layers more or less uniformly thick, from the entire area affected. This condition is apparent in Figures 4, 5, 6 and 7, and on the front cover of this bulletin. Rills and small gullies are also apparent. Typical examples of gully erosion are illustrated in Figures 1, 2, 3 and 9. When gully erosion is observed, sheet erosion is usually also taking its toll.

The rate or severity of water erosion is affected by many factors associated with properties of the soil, topography, climate, cultural practices, etc. Only a few of the more important can be given consideration here.

### The Physical Properties of the Soil

Physical characteristics have an important bearing on susceptibility to erosion. Soils which readily become dispersed or suspended in water are more susceptible than those which do not. The readiness with which soils disperse is, of course, related to the size of individual particles; but also to what is known as soil "structure", a term which concerns the tendency of soil particles to adhere together in clusters or "aggregates". Soils are said to have a desirable structure when the particles are well aggregated. Likewise, the presence of granules and clods of larger dimensions is indicative of good "tilth". The reason for this is to be found in the fact that aggregation is related to porosity, and porous soils tend to absorb water readily. On the other hand, soils characterized by poor structure tend to "puddle"

and to resist penetration by rain. Their behaviour is somewhat similar to that of ordinary bread flour which, upon being wetted, becomes sealed and almost impervious to water. When soils behave in this manner, loss of both water and soil is inevitable.

The question of soil structure may seem to be of scientific rather than of practical interest; but such is not the case, since cropping practices have an important bearing on the physical properties of the soil. For example, experiments conducted at the Soil Conservation Experimental Station at Clarinda, Iowa, have demonstrated that applications of organic matter to the surface layers of soil in the form of barnyard manure or green manure (sweet clover) had a pronounced effect on soil porosity. This was reflected in decreased run-off and an increase in available soil moisture.

**Climatic Factors**

Climatic factors have both direct and indirect effects on water erosion. As an example of a direct effect we may point to the fact that frost protects our prairie province soils from water erosion for some five or six months in the year. In the Southern States, however, winter protection is an important consideration in field practice. The seasonal distribution of rainfall and the frequency of heavy downpours are other important direct factors. Relatively enormous amounts of rain may cause little or no erosion if they are well distributed throughout the year; but two inches of rain in one hour where the annual precipitation is only 20 inches may constitute a great peril. Indirectly, climate affects erosion through its influence on the natural processes of soil formation.



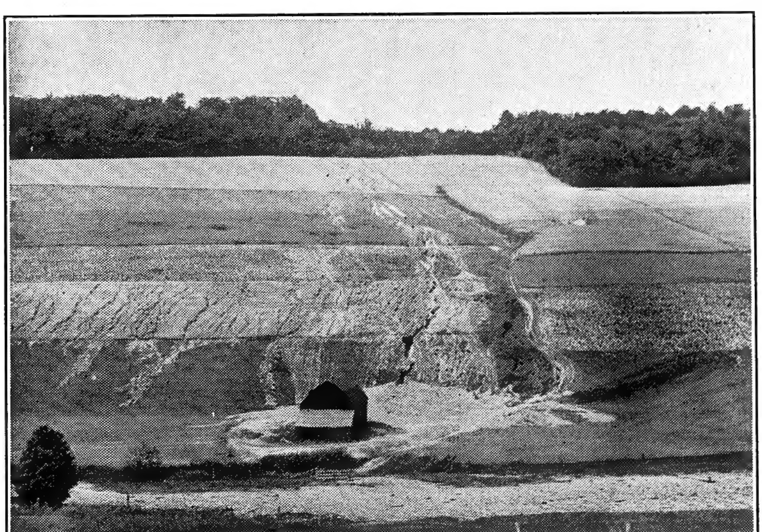

*Figure 1. Severe gullies (4-10 feet deep) due to water coming from cleared land above timber. Steuben County, New York, August, 1935.*

—(Courtesy of United States Soil Conservation Service.)

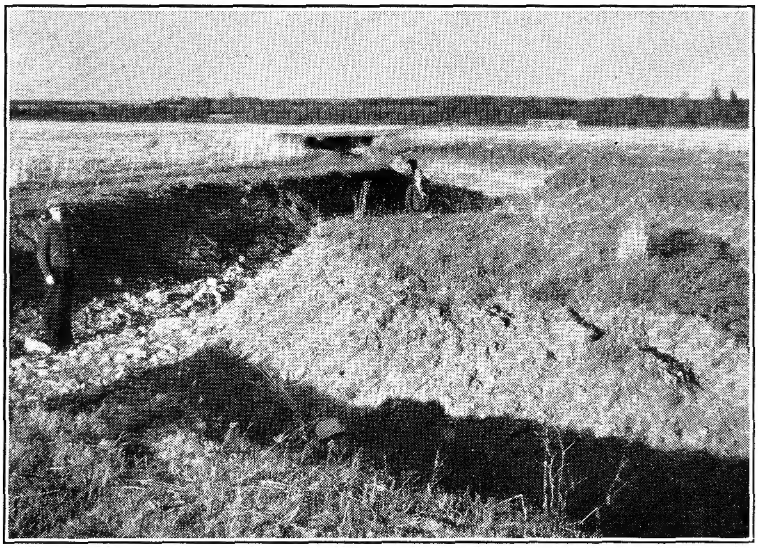

*Figure 2. Six-foot gully, with tributaries, cut through what had been a nice smooth field of black soil southwest of Halcourt, Alberta. The havoc dates practically from the summer flood of 1935. Photographed May, 1938.*

—(Courtesy of Mr. W. D. Albright.)

**Topography**

The extent to which land is sloping or rolling has a bearing which is obvious. We need not worry much about water erosion in the Red River Valley or on the Regina Plains. On the other hand, we cannot define the degree of slope which is safe because this depends upon so many other factors. Wherever there is an appreciable slope, there is danger of erosion sooner or later. It is estimated that 75% of the cultivated land in the United States is sufficiently sloping to be subject to erosion unless steps are taken to prevent it. It is doubtful if 25% of the cultivated land in the prairie provinces is sufficiently level to be entirely safe.

**Cultural Practices**

Management of the land may make or break the soil. In discussing the problem of water erosion in the grain growing areas of the Pacific Northwest, E.M. Rowalt writes: "Of all farming practices that contribute to loss of soil from cultivated fields in the Northwest, the clean summerfallow is plainly the principal offender."

Since we must return to the question of cultural practices when control measures are considered, further discussion at this time is unnecessary.

## LOSSES DUE TO WATER EROSION

The illustrations in this bulletin supply all that is necessary to a section on "losses". However, there are those who believe that subsoil is quite as productive as surface soil, and the following remarks are addressed to them.

It is true that we have some very deep fertile soils. An outstanding example is that of the Regina Plains where, possibly, considerable quantities of surface soil might be blown or washed away without any immediate effect on crop yields. In areas of rolling land, however, the fertile surface soil is relatively thin on the uplands and the removal of five or six inches of soil by erosion may render the land practically worthless. A field in central Saskatchewan which has already nearly reached this stage is illustrated on the front cover of this bulletin.

Any considerable amount of running water on bare summerfallow is evidence of damage to the land. While this is by far the most important phase of the problem, it is well to remember that, at the same time, the drought problem is being aggravated. In the prairie provinces, where excess moisture is the least of our worries, running water on cultivated fields is leaving the place where it is most needed, and moving to the low lying ground where the moisture conditions are more likely to be good. Therefore, if rainfall cannot be induced to soak into summerfallowed fields **where it falls,** losses of soil, which may be serious, will be suffered and one of the chief purposes of summerfallowing, which is to conserve moisture, will be defeated.

As an example of the effect on crop yields which may result if erosion is not checked, results of an experiment conducted in Minne-

*Figure 3. Many tons of fertile soil followed this route and are permanently lost. This is typical of summerfallowed fields observed in parts of central Saskatchewan in July, 1940.*

—(Author's photograph.)

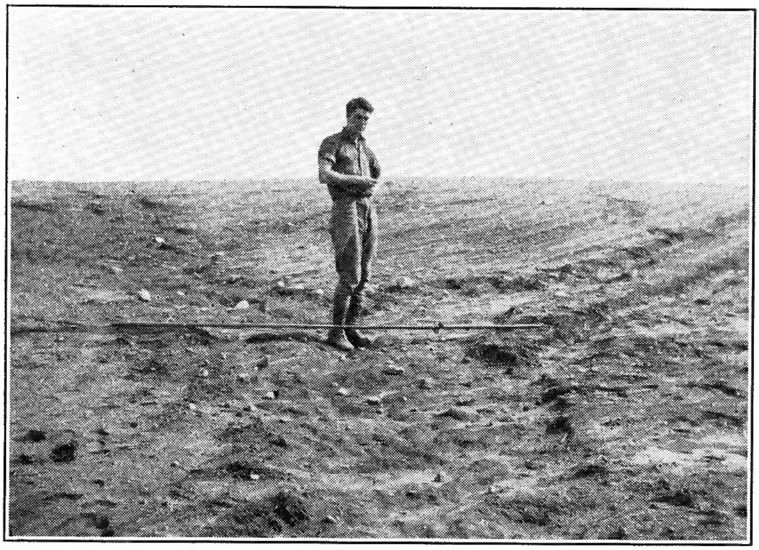

*Figure 4. Representative of the damage being done on the northern slopes of the Turtle Mountains in southwestern Manitoba.*
—(Courtesy of Mr. M. J. Tinline.)

sota by the United States Soil Conservation Service may well be quoted.

| | YIELD, BUSHELS PER ACRE | |
|---|---|---|
| Condition of soil | Oats | Barley |
| Less than 25% of topsoil lost | 51 | 47 |
| 25% to 50% of topsoil lost | 42 | 28 |
| 50% to 75% of topsoil lost | 35 | 23 |
| Over 75% of topsoil lost | 25 | 17 |

Many other experiments have yielded results essentially similar, and let us not forget that for all practical purposes **the topsoil is irreplaceable.**

Other losses due to water erosion of agricultural land are serious in many parts of this continent. Expensive water reservoirs become filled with silt, fertile lowlands are often ruined by deposits of silt and debris, road embankments are washed away, dangerous gullies are cut in road ditches, river floods are aggravated, and so on.

## CONTROL MEASURES

A discussion of controlling soil erosion in a publication such as this must necessarily be brief and general, because the details of control depend almost entirely upon local conditions in the district and even on the individual farm concerned. One of two purposes must be achieved. Either the rain must be absorbed where it falls, and snow where it thaws, or, if this is impossible, excess water which runs off must be prevented from carrying soil with it. If rain is made to run away slowly, little or no soil is lost. Wherever possible, run-

off should be prevented altogether and aside from excessively heavy downpours, steeply sloping land and the occurrence of some flow when the snow is thawing, this can be achieved in the prairie provinces.

**Tillage Methods**

Tillage methods and cropping practices are by far the most important factors in preventing run-off and the consequent loss of soil. When erosion conditions are not too severe, the methods commonly adopted for the control of soil drifting may be effective. The spike-tooth harrow, the disc harrow or any other implement which pulverizes the soil too finely should be avoided or used with great discretion. The method so well illustrated in Figure 8 will unquestionably tend to reduce or eliminate run-off on slight or moderate slopes. A cloddy surface and trash cover would have prevented much of the damage suffered by summerfallowed fields in recent years.

**Crop Rotations**

The problems of preventing erosion and maintaining soil fertility on the open plains are indeed knotty. Whether the two and three

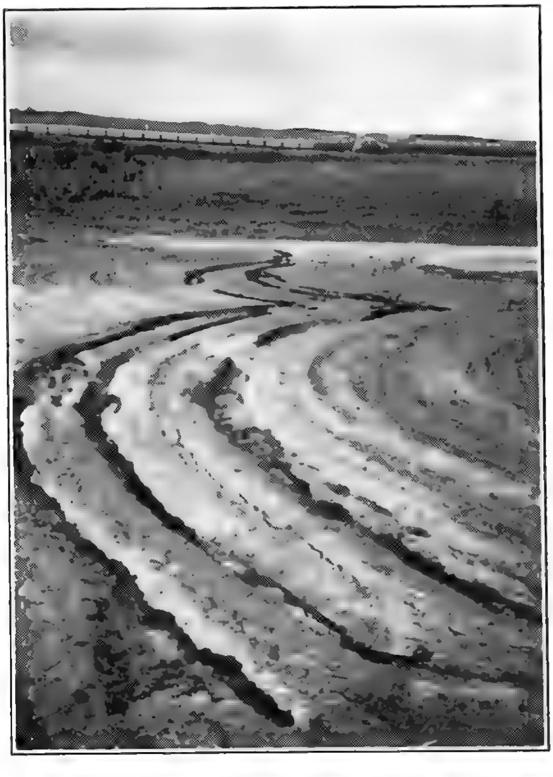

*Figure 5. Rill erosion down tracks of a duckfoot cultivator. Photograph taken in July, 1940, near Yorkton, Saskatchewan.*

—(Courtesy of Professor John Mitchell.)

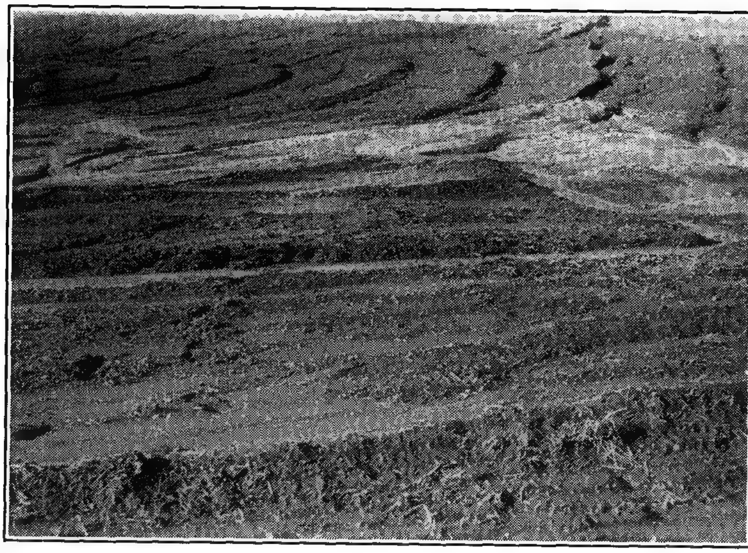

*Figure 6. This field had been single-disced. The middle of a disc track provides an ideal channel for water to run off the field. July, 1940, in the Theodore-Springside district in Saskatchewan.*

—(Author's photograph.)

year systems of grain-fallow and grain-grain-fallow now so widely adopted can be continued indefinitely remains to be seen. Some of us entertain doubts. The addition of grasses, or grass-legume mixtures, involves practical and economic problems, particularly in certain districts. Due to the difficulty often encountered in attempts to establish stands of grass, its place in short rotations may be questioned. However, the introduction of improved grasses and the adoption of better methods may alter this picture. If short rotations which include hay or pasture crops are impracticable, then it may be advisable, or even necessary, to establish semi-permanent fields of grass in order to preserve the land. If the fields illustrated in Figures 3 to 6 can be preserved in no other way, they should be set aside for grass, notwithstanding the economic problems thus entailed. It is better to have grass land than waste land.

In most of the park and wooded areas of the prairie provinces, there are no serious technical difficulties involved in growing grasses, legumes, or grass-legume mixtures. The advisability of sowing forage crops at regular intervals is well recognized by many progressive farmers. Many excellent hay fields may now be found in the northern areas; but, from the point of view of the soil conservationist, which all of us should be, there are not enough. Of course, the reason is largely economic, but one is tempted to wonder at this time if increased attention to mixed farming would entail more serious marketing problems than those we now face as grain farmers. Upon this question I am not qualified to write. I firmly believe, however, that in any successful programme of water erosion control, forage crops will play a leading part.

### Contour Tillage

Many tillage implements leave the land more or less ridged. Indeed, deliberate ridging is an important aspect of soil drifting control. The use of implements, such as the duck-foot cultivator, up and down the slopes of rolling land often seriously increases the extent of water erosion (See Figures 5 and 6). As a result, operating tillage machinery on the contour instead of straight up and down the fields has become a common practice in soil erosion control. Contour tillage retards run-off by forming a continuous series of ridges at right angles to the slope. On relatively broad sweeping slopes, the inconvenience of contour tillage is at least partly offset by a saving in fuel consumption. Unfortunately, much of the rolling land in the prairie provinces consists of relatively small knolls, depressions and sloughs or "pot-holes". On land of this kind contour tillage is impossible or, at least, impracticable.

### Contour Strip Cropping

Just as strip farming, in conjunction with appropriate tillage methods, has played a leading role in the control of soil drifting on the western plains of Canada and the United States, so has contour strip cropping been adopted in many parts of the United States in the water erosion control programme. This practice involves the alternation of strips of erosion susceptible crops such as cotton or tobacco with erosion resistant crops such as grasses and clovers. Since the strips are planted on the contour, the retarding effect on run-off is obvious. The width of the strips is determined by local conditions including degree of slope, frequency of heavy downpours, soil type, crops grown, etc.

*Figure 7. Sheet erosion on Palouse silt-loam in Whitman County, Washington. This field was summerfallowed in 1933 and planted to fall wheat. The photograph was taken on the 29th of January, 1934. The slope in the upper part of the picture lost approximately 50 to 75 tons of soil per acre.* —(Courtesy of United States Soil Conservation Service.)

*Figure 8. This picture shows winter wheat stubble disc-tilled, September, 1936, near Johnson, Washington. According to E. M. Rowalt, "mixing all or a part of the residue from the harvested crop with the surface soil is one practice that may be used as a measure for erosion control in the Pacific Northwest Wheat Belt."*

—(Courtesy of United States Soil Conservation Service.)

## Terracing

If water erosion cannot be prevented by a combination of good tillage, appropriate cropping practices and contour farming, the use of modern broad-base terraces (See Figure 10) combined with other control measures may make crop production possible. Terraces, of course, follow the contour and may be either level or provided with a gentle grade. The construction of level terraces presupposes that the interruption to running water will result in complete absorption of rainfall. If, however, absorption is not complete, and water overflows the terrace ridges, the resulting damage is likely to be greater than if terraces had not been built. Consequently, terraces are usually constructed with a slight grade, and outlets for excess water at the terrace ends are provided. In this way water is compelled to move off so slowly that little or no soil is lost.

The possible value of terraces in preventing erosion in the prairie provinces is being investigated at the Dominion Experimental Farm, Brandon, Manitoba, and at the Dominion Experimental Stations at Swift Current, Saskatchewan, and Beaverlodge, Alberta. Before undertaking terrace construction, it is essential that the advice of a professional agricultural engineer be secured.

It is important to remember that terracing alone will not save the soil, but may be valuable, indeed sometimes indispensable, when used in conjunction with soil conserving tillage and cropping practices.

### Grass and Forest

There may be cultivated fields in the West which cannot be saved by any combination of the methods described above. Such land should be restored to grass or trees, and under no circumstances brought under cultivation again.

### Gully Control

Gullies formed by accelerated erosion will grow indefinitely unless control measures are adopted. Of course, the most important consideration is that of keeping the water in the fields which "feed" the gully. This is sometimes impossible and so it may be necessary to "stabilize" the gully and thus allow water to flow down without carrying soil along with it. This can usually be achieved by establishing grass throughout the gully. The sides, usually steep, should be rounded off and the loose soil levelled in the channel. This will

*Figure 9. The field in the foreground is summerfallow, and the one in the background is a mixture of brome grass and alfalfa sown with a nurse crop in 1939. There was no sign of erosion in the hay field though the slopes were in general quite as steep as those on the fallow. Photographed in July, 1940, in the Theodore-Springside district in Saskatchewan.*

—(Author's photograph.)

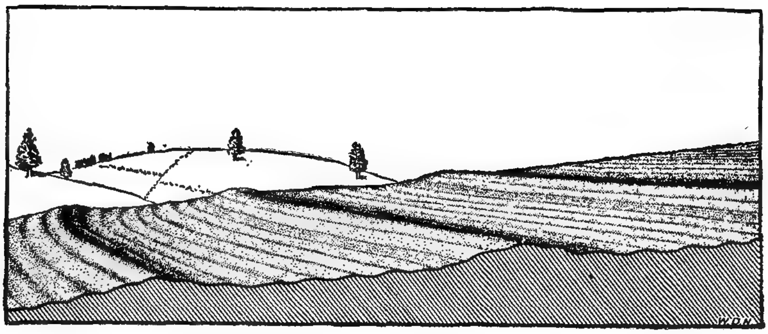

*Figure 10. Diagram illustrating the use of modern terraces as commonly constructed on cultivated hillsides.*

—(Courtesy of McGraw-Hill Book Company, Inc.)

both widen and raise the channel, and replace the abrupt sides with gentle curves. In order to give the grass a chance it will usually be necessary to construct temporary diversion ditches which can be filled in when the grass cover is well established. In very deep gullies, or when for one reason or another diversion ditches cannot be used, the construction of check dams at intervals in the gully may be necessary.

Mr. W. D. Albright emphasizes the importance of the use of broad-bottomed grass runways in the prevention of gullies. These should be provided in all small coulees or "draws" in cultivated fields where run-off is observed to concentrate. In such places, grass may be established readily before gullies form, but only with difficulty afterwards.

If faced with a gully control problem, the safest plan is to consult the local district representative or the nearest experimental farm. Guidance by an experienced advisor may save much useless work.

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## GENERAL DISCUSSION

Prairie province soils are suffering irreparable damage from water erosion, and this must be stopped regardless of cost. The amount of damage already done and the danger of further loss cannot be estimated without the results of a comprehensive survey. No such survey has been made, and this should be the first step.

Any programme of control necessarily involves more or less serious practical and economic problems. Few farmers can adopt soil conserving practices if a substantial reduction of income is involved, even though the ultimate result would be increased income. This is a national problem and the nation will have, sooner or later, to meet it.

The main purpose of this bulletin is to draw attention to an unquestionable menace. It was necessary to include a brief discussion of control methods even though it be inadequate. A full discussion, however, would involve almost the entire field of good farm practice. No one can deny that overemphasis on small grains and the necessity for summerfallowing have given rise to the problem. The appalling increase in the distribution of perennial weeds must inevitably lead to more summerfallow and more tillage on each field. Hence we may expect much more erosion in the future unless preventive measures are adopted.

Finally, I desire to suggest that if we should find that we are faced with the necessity of reducing our wheat acreage, first consideration should be given to land which is clearly suffering irreparable damage as a result of the wheat-summerfallow system.

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## ACKNOWLEDGMENTS

I am indebted to Mr. W. D. Albright, Superintendent of the Dominion Experimental Sub-Station, Beaverlodge; to Professor John Mitchell, Professor of Soils, University of Saskatchewan; and to Mr. M. J. Tinline, Superintendent of the Dominion Experimental Farm, Brandon, for criticism of the manuscript.

The courtesy of the McGraw-Hill Book Company, Inc. in granting me permission to reproduce Figure 48 in, "Soil Erosion and Its Control" by Professor Q. C. Ayres, and the poem which appears on page 19 of the same book is gratefully acknowledged.

I am also indebted to the United States Soil Conservation Service for permission to use the photographs reproduced in Figures 1, 7 and 8; to Mr. W. D. Albright for Figure 2; to Professor John Mitchell for Figure 5; and to Mr. M. J. Tinline for Figure 4.

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